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SEAMOUNTS, DIRECT BLAST AND VOLUME REVERBERATION UPGRADES

SAIC-88/1961

30 November 1988

Science Applications International Corporation
An Employee-Owned Company

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Prepared for

AEAS Program Office
Office of Naval Research

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Section 1
INTRODUCTION

This document describes upgrades made to the SAIC Active System Model (SASM). Major enhancements include seamount echos, direct blast and volume reverberation along with enhanced plot capabilities. A data flow diagram in Figure 1-1 shows the files and plots that are available.

The SASM is a long range bistatic prediction model which estimates system performance for large ocean areas that are within 500 nm of the receiver. In order to efficiently compute long range system performance, relatively coarse angular and range step sampling is used. While this sampling is used to compute the large scale acoustic variations, a higher resolution method is employed to model the discrete returns from seamounts and direct blast arrivals.

Significant changes were made in the ASERT module with respect to the processing of the bathymetry data. Bathymetry is treated as a surface rather then a collection of two dimensional radials. A three dimensional analysis of this surface is performed prior to ASTRAL which allows the identification of seamounts within the range of interest.

A pattern recognition algorithm determines the position, height and other parameters for each seamount. Once located, the seamounts are removed from the bathymetry data and modeled as discrete features in both the REVERB and SYSMOD modules.

As in the NOP Baseline model V1.2, ASTRAL receives bathymetry profiles along equally spaced radials. These radials are retrieved from the bathymetry surface which has

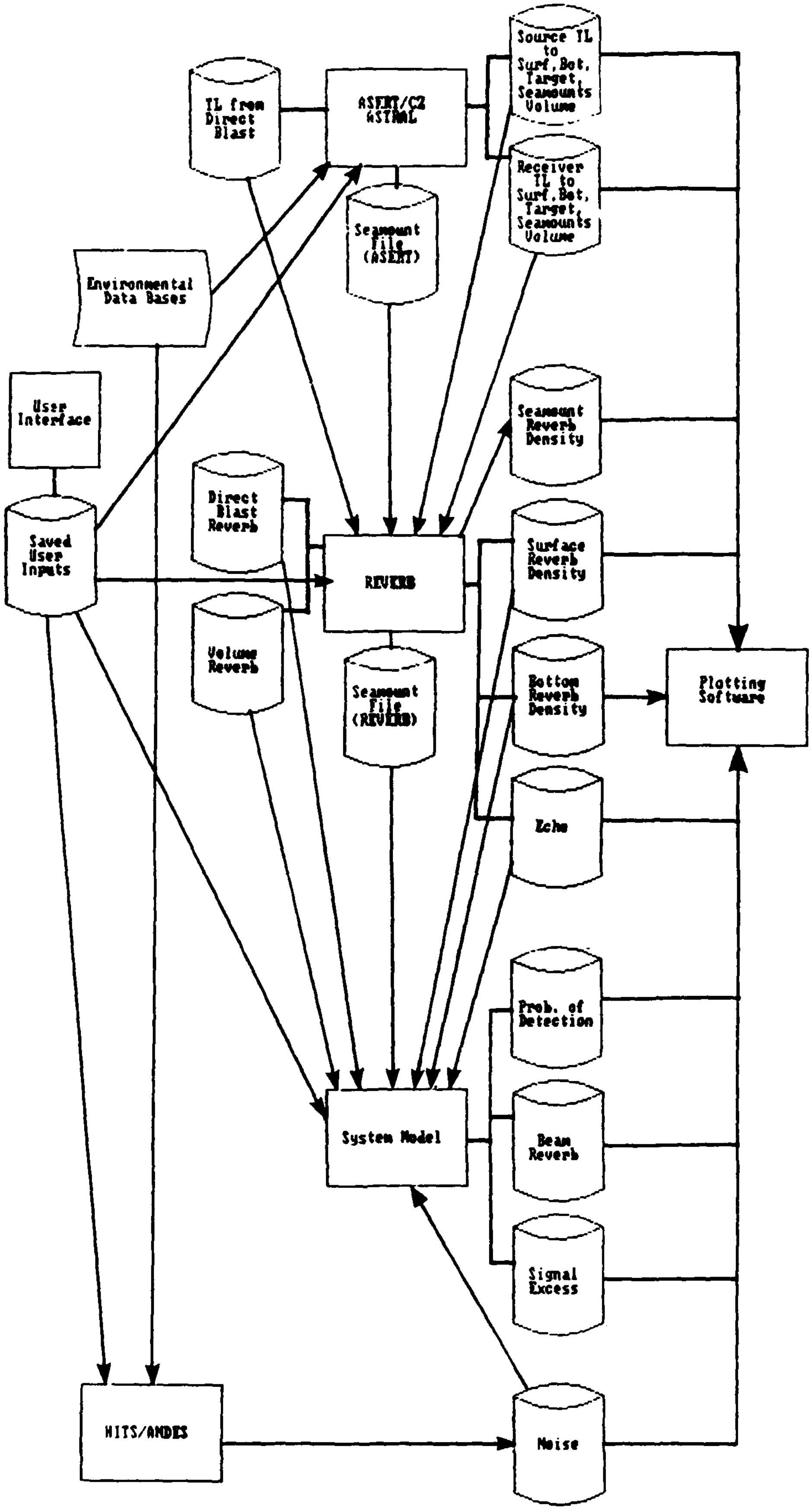


Figure 1-1. Flow Diagram of Model Inputs/Outputs

had the seamounts removed. The propagation loss is computed using the seamount free (smooth) bathymetry.

Three additional ASTRAL TL depths are computed by evaluating the heights, ranges and target strengths of the extracted seamounts. ASTRAL is then used to estimate the propagation loss at these three seamount depths in addition to the surface, target and bottom depths.

The direct blast is modeled as a series of arrivals which travel in a vertical plane from the source to the receiver. For each range step multiple modes (10 maximum) are retained.

Volume reverberation requires an additional TL run at the volume scattering depth. The TL to this depth is combined with a volume scattering strength to compute the volume reverberation.

The addition of seamounts, direct blast and volume reverberation has made version 1.3 a "dual resolution" model which simulates discrete arrivals while efficiently computing system performance over large areas.

Section 2

ASERT: DATA PREPARATION FOR ASTRAL

2.1 OVERVIEW AND PURPOSE OF ASERT UPGRADES

The purpose of upgrading ASERT was to compute the TL required to model seamounts, direct blast and volume reverberation effects.

In order to model the seamount returns, a substantial amount of ASERT bathymetry processing is required. The ASERT source run contains the major changes and it is here that the bathymetry is processed and seamounts are extracted. Each seamount has a set of parameters computed which relate to its position, height, depth and target strength. Three seamount TL depths are determined by an analysis of the extracted seamount depths. These additional TL values are used by REVERB to estimate an integrated TL to each seamount.

The direct blast is modeled by computing the TL along the bearing from the source to the receiver at the receiver's depth. Unlike the source and receiver TL files, the direct blast TL file contains the intensities for multiple modes (10 modes maximum) at each range step.

Volume TL is computed at a depth which is representative of the center of a volume scattering column and will be used to compute volume reverberation.

Modification of the transmission loss module (ASTRAL) was not required for the enhancements. ASTRAL computes TL at additional depths (three seamount and one volume depth) and computes multiple modes along the source to receiver bearing for the direct blast.

2.1.1 ASERT Model Overview

The ASERT model performs sequentially the following tasks:

- Initialization - Open database files and read header records; read the user's input file
- Environmental Data Extraction - Select bathymetry and water mass indexes over the area of interest. Retrieve sound speed and geoacoustic parameters along radials.
- Bathymetric Processing - Median filter bathymetry grid and process so seamount locations can be determined.
- Seamount Extraction - Locate seamounts and compute their physical parameters. Write seamount parameter file.
- TL Computation for Source - Compute source transmission loss at surface, bottom, target, seamount depths and volume scattering depth. Use bathymetry radials from the filtered grid.
- TL Computation for Receiver - Compute receiver transmission loss at surface, bottom, target, seamount depths and volume scattering depth. Use bathymetry radials from the filtered grid.
- TL Computation for Direct Blast - Compute source to receiver transmission loss at

receiver depth along the source to receiver radial using the filtered bathymetry. Retain multiple modes (10 maximum) for each range step.

2.2 ASERT SOURCE RUN

The ASERT source run contains the major changes required to process the bathymetry and extract seamounts. Bathymetry data is read into a grid and seamounts are determined by their height deviations above the local median sea floor.

2.2.1 Bathymetry Grid Definition

The processing of bathymetry data is handled using two dimensional grids. Bottom depths are extracted over the area of interest from the one sixth degree SYNBAPS data base and placed in a grid. A filter operation is performed on the extracted bathymetry which results in other grids. Below is a list of the grids which are used in bathymetry processing.

- Bathymetry Grid — Depths in meters measured from sea level to the sea floor as retrieved from the SYNBAPS data base.

- Low Pass Grid — Median depth in meters as determined by a 25 cell rectangular filter which operates on the "Bathymetry Grid".

- High Pass Grid — Created by subtracting the Bathymetry Grid from the Low Pass Grid. Contains both positive and negative deviations of the bathymetry from the "Low Pass grid".

- Seamount Grid — Created by setting all values in the "High Pass Grid" to zero if they did not exceed 400 meters. Contains positive values which are greater than 400 meters. This grid is used to determine seamount positions.

2.2.2 Bathymetry Processing

Bathymetry processing proceeds sequentially in the following order:

- Extraction of Area — Extract bathymetry over area of interest and place in bathymetry grid.
- Filter Bathymetry — Median filter input bathymetry and place in low pass grid.
- Compute High Pass Grid — Subtract the bathymetry grid from the low pass grid.
- Compute Seamount Grid — Zero all bathymetry elevation values less than 400 meters.
- Localize Seamounts — Determine seamount positions using the seamount grid.
- Compute Seamount Statistics — Compute statistics for each seamount based upon individual physical dimensions.
- Output File — Write out the low pass grid and the seamount statistics file.

The bathymetry processing is shown in Figure 2-1 in cross section form. These cross sections show the relationship of the processed bathymetry to the retrieved bathymetry.

Seamount bathymetry processing is described below.

2.2.3 Area Extraction

Bathymetry is retrieved from a one sixth degree SYNBAPS data base and placed in the bathymetry grid. The retrieved area is computed on the basis of the user input source-receiver separation and maximum range. A perspective plot of the bathymetry grid is displayed in Figure 2-2. This area is located just south of the Aleutian Island chain and covers a quarter of a million square nautical miles. Each rectangular grid cell represents a one sixth of a degree data point. The large wall on the right side of the plot is the Aleutian Trench which has 4000 meters of relief. The isolated elevation peaks represent seamounts which vary in height from 400 to 1500 meters. The larger seamounts occupy 10 to 12 of the grid cells.

2.2.4 Bathymetry Filtering

The identification of seamounts is approached by recognizing that seamounts have small spatial extents over which relatively large changes in elevation occur. A filtering process is used to separate these short period elevation highs from the smoothly varying elevation changes typical of the sea floor. The bathymetry processing objective is to identify and remove the seamounts and model them individually as discrete targets. The smoothly varying elevation changes are retained and used as input to the TL computation.

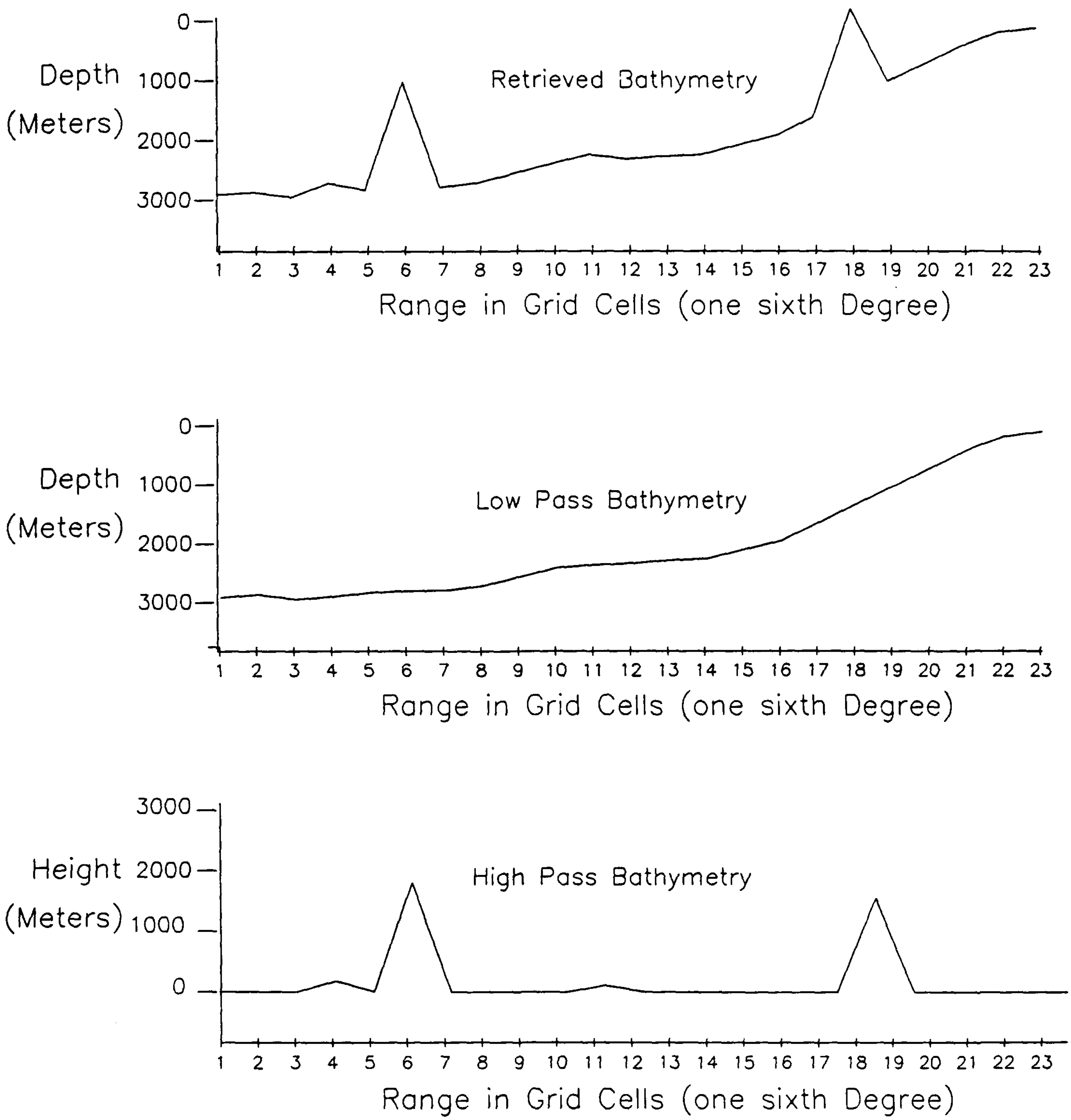


Figure 2-1. Bathymetry Processing Cross Sections

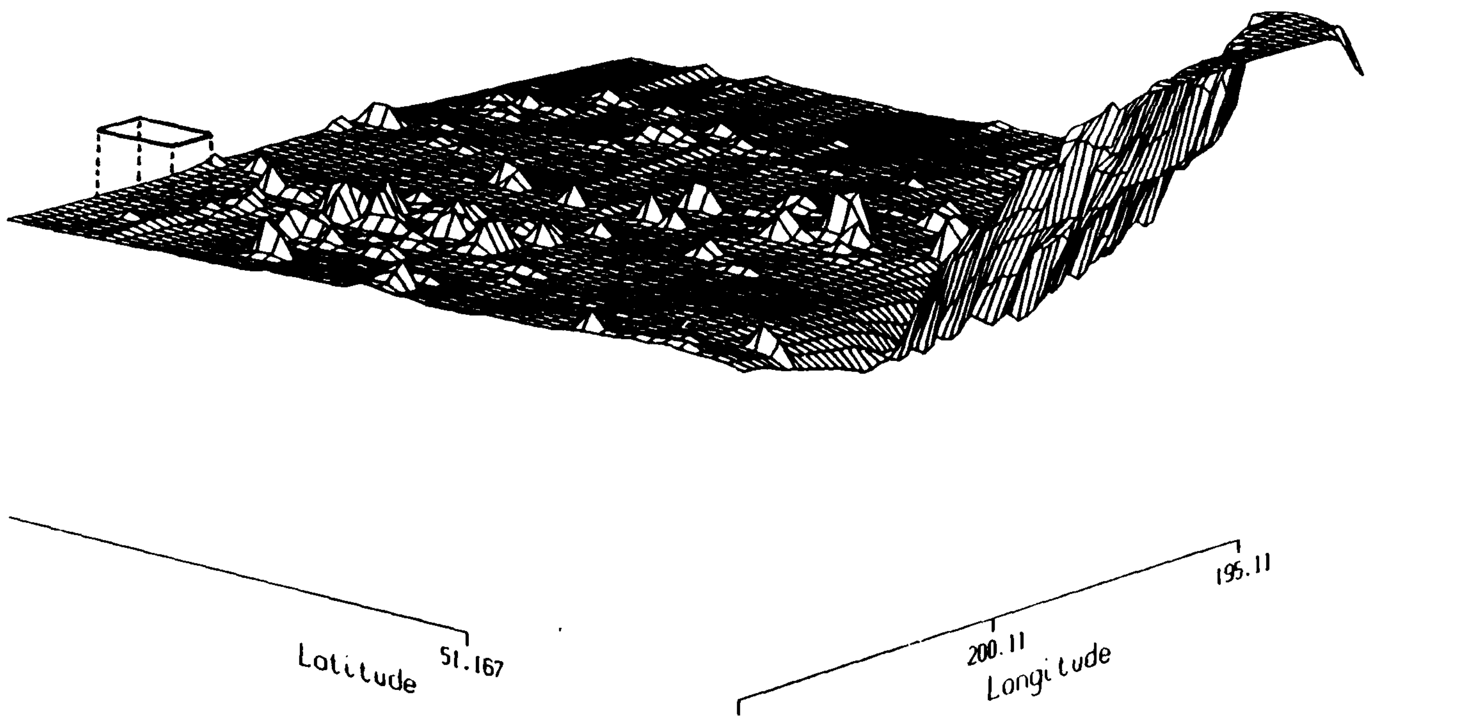


Figure 2-2. Bathymetry Perspective with Filter

A two dimensional rectangular median filter is used to filter the bathymetry grid. The median depth value within the filter is computed and output to the low pass grid. This value is associated with the location of the filter center point. A filter was selected which was large enough (contains enough cells) so that most seamounts would not occupy a majority of the filter cells. The filter output is a good estimate of the local sea floor depth. The filter shown in Figure 2-2 is five cells on a side (25 total cells) which is the default size.

A seamount is displayed on a one sixth degree bathymetric grid within the default size median filter in Figure 2-3. The contour lines are depth below sea level. The cells which lie outside of the outer most seamount contour and within the filter make up the majority of filter cells. The depth output at this filter position will be a value which lies outside of the seamount contours.

The depth distribution of the cells within the filter shown in Figure 2-3 are shown in Figure 2-4. The cells within the filter are arranged in decreasing depth. The filter passes the median value associated with its center point and attenuates the shallower depth values associated with the seamount. The output depth for this filter position is not influenced by the shallower seamount depths.

The low pass grid is shown in Figure 2-5. The seamounts have been attenuated while the longer period Aleutian Trench has been unaltered. The elevation peaks around the perimeter of the grid are filter "edge affects" and do not cause a problem because the area extracted for processing is selected slightly larger than the maximum range of interest input by the user.

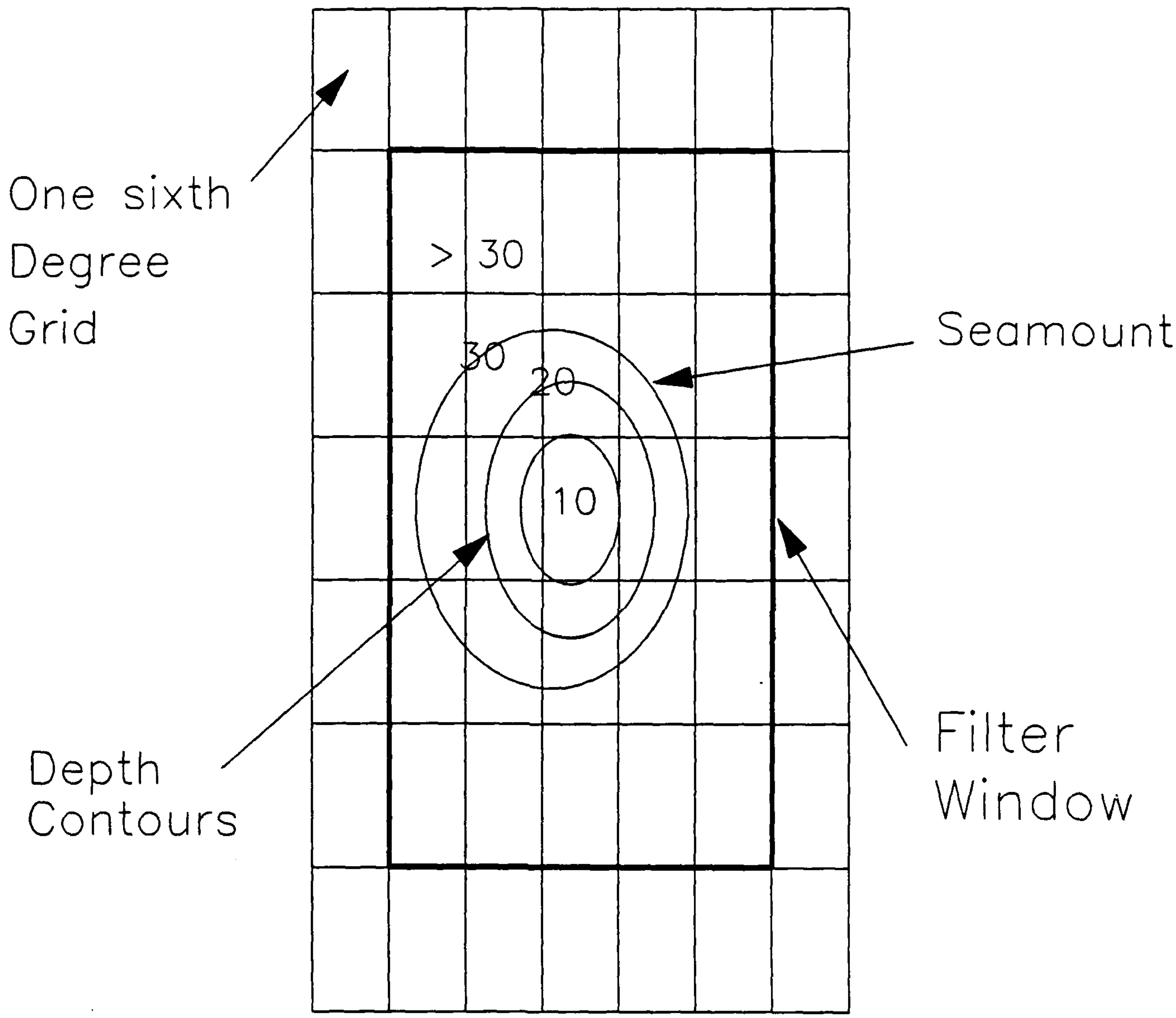


Figure 2-3. Median Filter Plan View

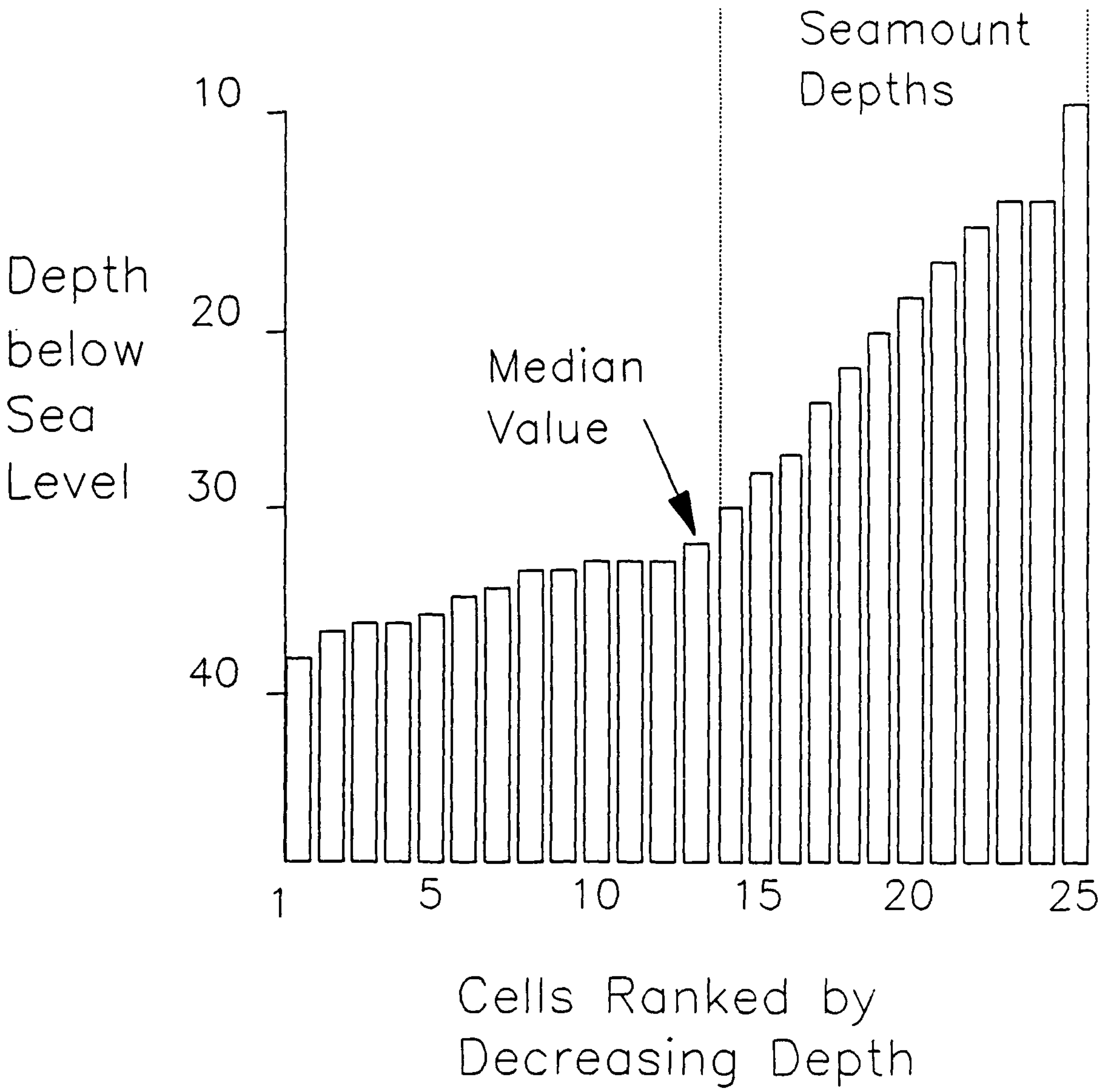


Figure 2-4. Median Filter Sea Floor Depth Distribution

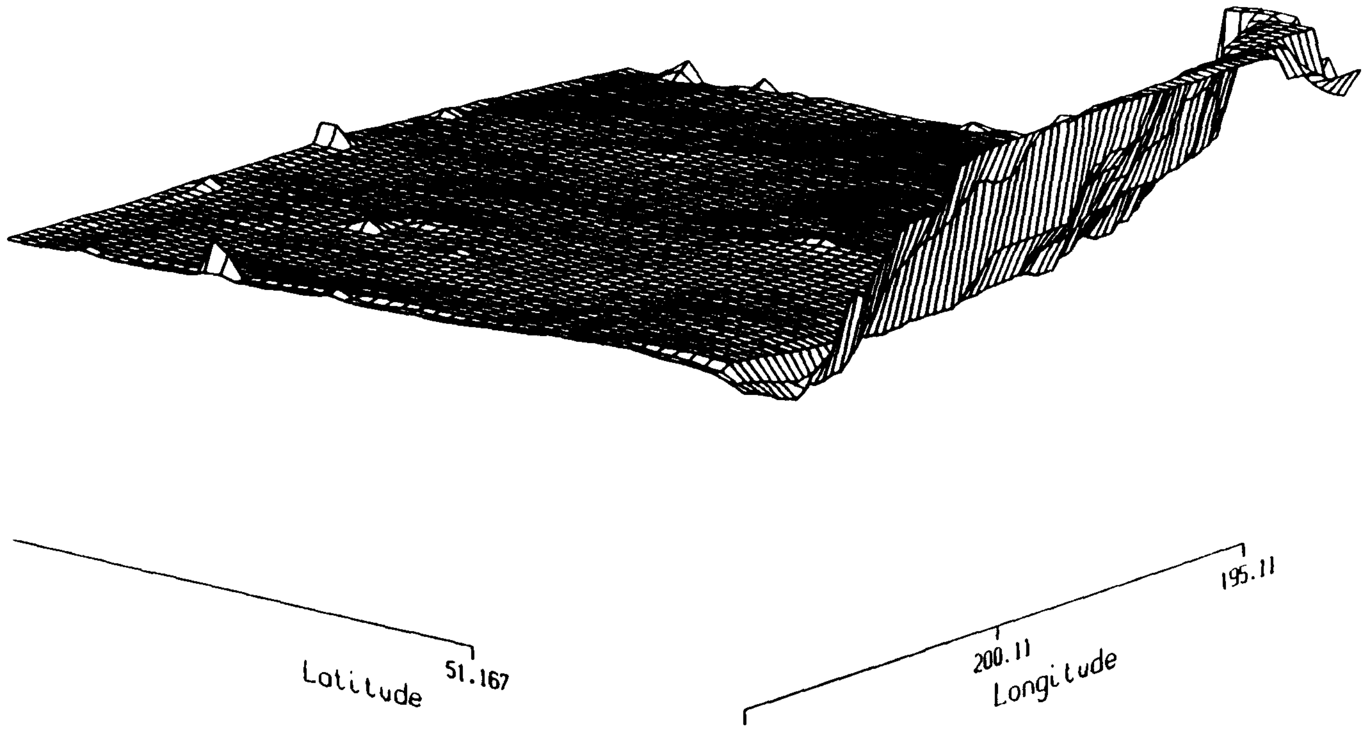


Figure 2-5. Low Pass Bathymetry Perspective

2.2.5 Localization of Seamounts

Seamounts are localized by subtracting the bathymetry grid from the low pass grid. This subtraction is performed on a cell by cell basis and yields a height value which represents the deviation from the local median sea floor. These deviations are placed in the high pass grid.

Seamounts reside in the grid cells which contain positive deviations. The subtraction yields the high pass grid which is near zero except for short period elevation highs and lows. A perspective of the high pass grid is shown in Figure 2-6. A threshold process is used on the high pass grid which zeros each cell if the height is 400 meters or less. The seamount grid results which contains only the short period elevation highs. The seamount grid was contoured and is shown in Figure 2-7. The positions and heights of the seamounts are as indicated.

A contouring algorithm operates on the seamount grid and identifies the grid cells occupied by seamounts. An analysis is performed on these cells to determine values for a set of seamount statistics.

2.2.6 Seamount Statistics

Statistics for each seamount are determined using the seamount and the bathymetry grids. Seven statistics are determined for each seamount which are shown graphically in Figure 2-8. These statistics along with the ASTRAL TL depth are written to the output file "SEAMOUNT.RID" and are listed below:

- Bearing - Bearing (degrees) from the receiver to the center of the seamount.

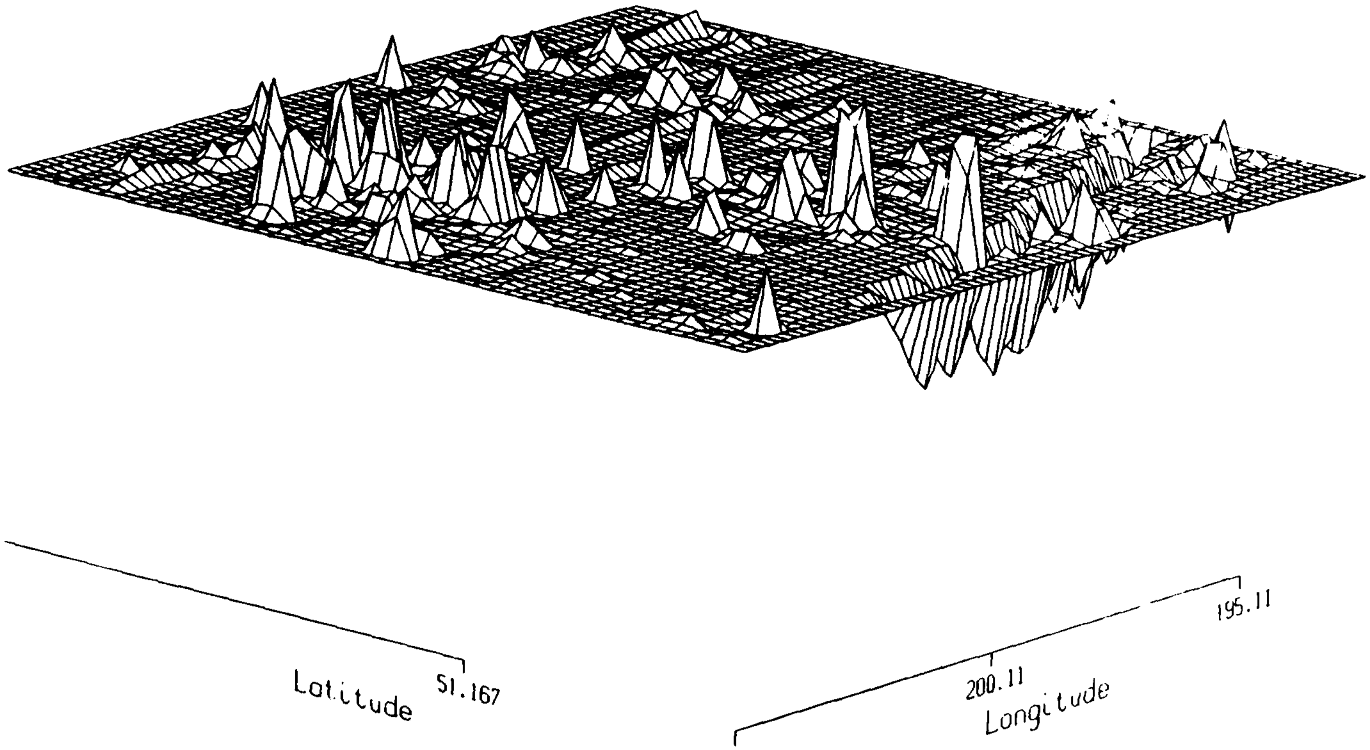


Figure 2-6. High Pass Bathymetry Perspective

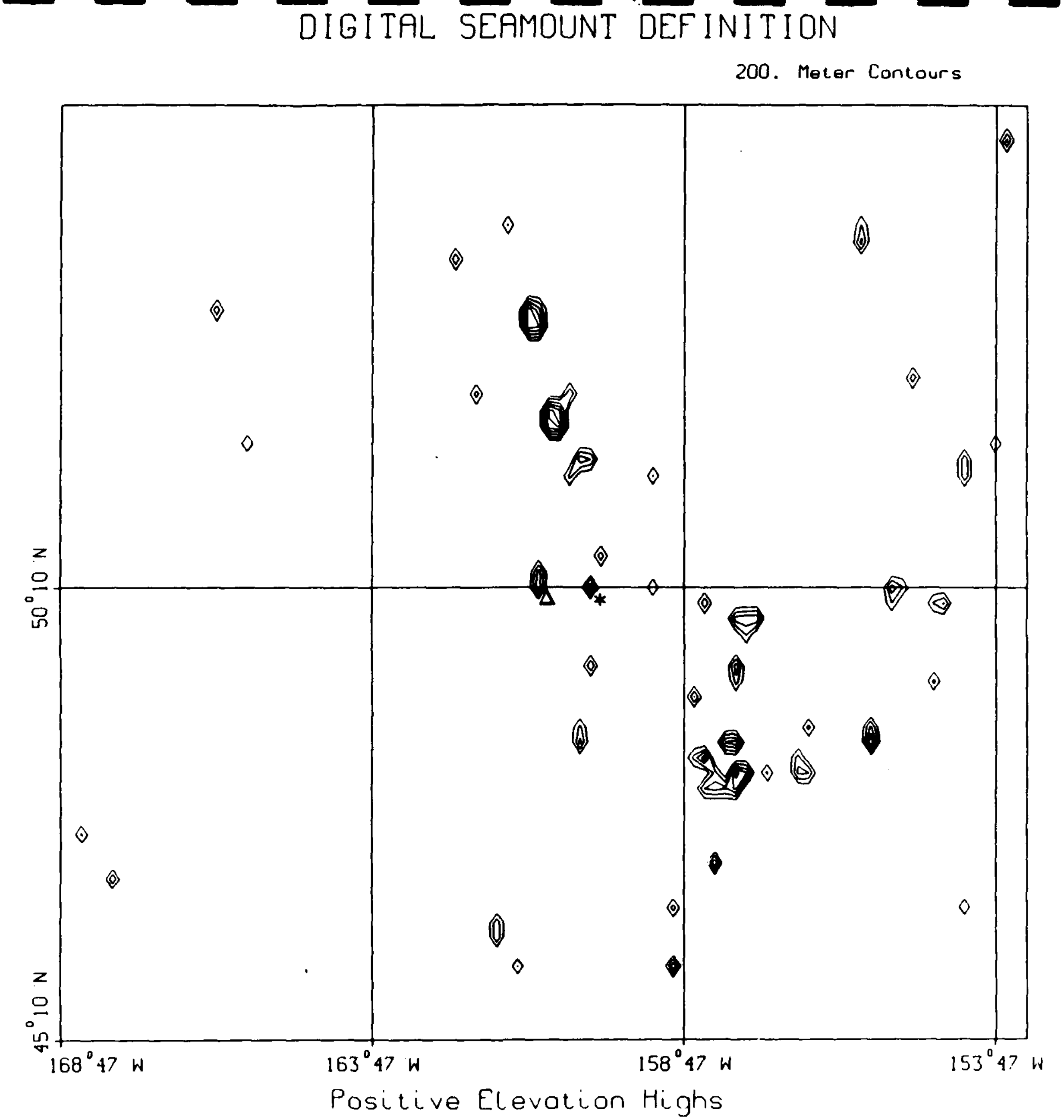
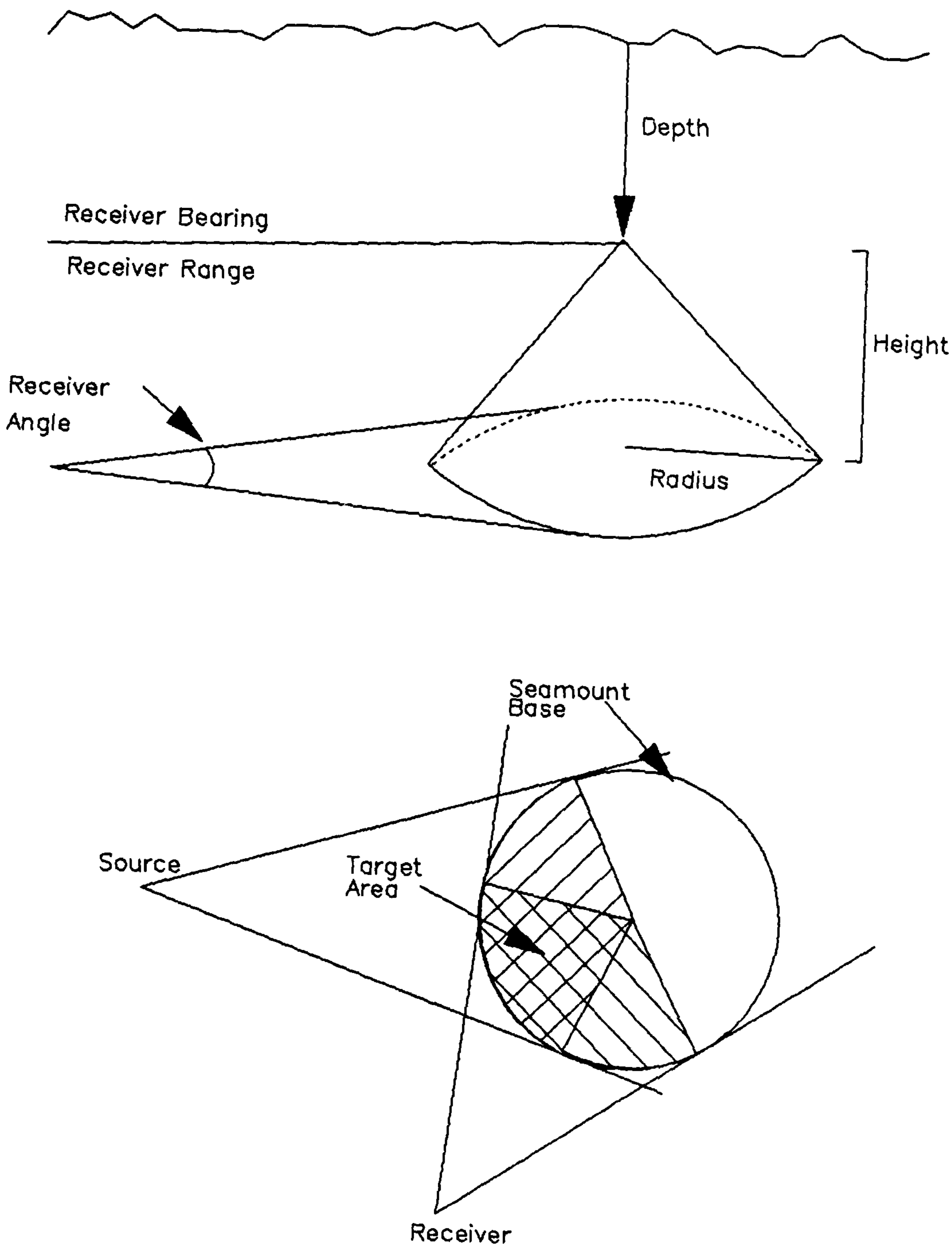


Figure 2-7. Contour Plot of Seamount Locations and Heights



$$TS = 10\log(\text{Target Area}) + 10\log(\text{slope}/90)$$

Figure 2-8. Seamount Statistics

- Range - Nautical miles from the receiver to the center of the seamount.

- Height - Distance in meters that the seamount extends above the local median sea floor. Computed by determining the maximum relative height of all cells occupied by each seamount.

- Depth - Distance in meters from sea level to the top of the seamount.

- Radius - The seamount base radius computed by assuming the seamount is a right circular cone with a 15 degree slope and height given above.

- Target Strength - In dB computed as a function of the Target Area "seen" by both source and receiver.

  TS=10 log(Target Area) + 10 log(b/90)

  where Target Area is the vertical cross sectional area and b is the slope of 15 degrees.

- TL Depth - Depth in meters which corresponds to one of the three ASTRAL seamount TL depths. Computed by analysis of all seamounts found within area of interest.

- Receiver Angle - The angle in radians that the base of the seamount subtends when viewed by the receiver.

2.3 ASERT RECEIVER RUN

2.3.1 Overview

The receiver run follows the source run and computes TL at the same range step as the source run. The receiver run does not have any seamount processing functions as all the bathymetry processing occurred previously during the source run. The ASERT receiver run performs sequentially the following tasks:

- Initialization - Open database files and read header records; read the user's input file

- Extraction of Environmental Data - Select smoothed bathymetry and water mass indexes by opening up file "FILBATHY.RID". Retrieve sound speed and geo-acoustic parameters from data bases along radials.

- Computation of Transmission Loss - Compute transmission loss at surface, bottom, target, seamount depths and volume scattering depth.

2.4 ASERT DIRECT BLAST RUN

2.4.1 Overview

The direct blast computation is unique in that TL is computed for the receiver depth along a radial from the source to the receiver. This is in contrast to the TL computation for the source and receiver which compute multiple radials along multiple depths. Also in contrast to the source/receiver TL computation is the multiple modes that are saved at each range step. The direct blast TL modes are

not summed at every range step. The ten most intense modes are retained at every range step with their associated arrival times and intensities.

The ASERT direct blast run performs sequentially the following tasks:

- Initialization - Open database files and read header records; read the user's input file

- Extraction of Environmental Data - Select smoothed bathymetry and water mass indexes along the source to receiver radial by reading file "FILBATHY.RID". Retrieve sound speed and geo-acoustic parameters from data bases.

- Computation of Transmission Loss - Compute transmission loss at the receiver depth.

2.5 ASERT OUTPUT FILES

ASERT creates a seamount statistics file "SEAMOUNT.RID" before the creation of the source, receiver and direct blast TL files. A temporary environmental file is created during the source run which contains the low pass bathymetry grid and the water mass index data. This file is used by both the receiver and direct blast runs.

2.5.1 Seamount Statistics File

The seamount statistics file is written before the ASTRAL source run and contains variables which are described in detail in Section 2.2.6.

This file is a formatted ASCII file which contains a header record followed by one record for each seamount. The file is read by REVERB and deleted after REVERB successfully computes the echo and time duration for each seamount. The file is named "SEAMOUNT.RID" and its structure is as follows:

Seamount Header Record

Variable	Type	Dim	Unit	Purpose
NUM_SEA	INT	1	n/a	Number of seamounts found in the area of interest
NUMSRC	INT	1	n/a	Number of TL depths for seamounts.
SRCDEP(1)	INT	4	m	Shallowest seamount TL Depth
SRCDEP(2)	INT	4	m	Middle Seamount TL Depth
SRCDEP(3)	INT	4	m	Deepest seamount TL Depth

For each seamount a data record is written which contains 8 values. There is a maximum of 200 seamount records. The following table lists the variables for each seamount.

Variable	Type	Unit	Description
BEARING	REAL	Deg	Bearing from receiver to seamount center
SMRANGE	REAL	NM	Range from receiver to seamount center
T_S	REAL	dB	Target strength of seamount
SMDEPTH	REAL	m	Depth to top of seamount
HEIGHT	REAL	m	Height above local median sea floor
RADIUS	REAL	NM	Radius of seamount base

SEATD	REAL	m	One of three ASTRAL TL depths which represents TL to the seamount.
SM_ANG_SPREAD	REAL	Rad	Angle that is subtended by the seamount base at the receiver

2.5.2 Filtered Bathymetry and Water Mass File

The ASERT source run is the first which is executed. During this run a temporary file is created which will be used by the receiver and direct blast runs which follow. The file contains both the low pass bathymetry grid and the Water Mass indexes for the area of interest. The creation of this file reduces the overhead required by the receiver and direct blast run associated with the loading of environmental data from the environmental data bases. This file is deleted after successful completion of the direct blast ASERT run.

File Name : FILBATHY.RID

A header record is written with variables in the following order:

Variable	Type	Dim	Unit	Purpose
MAXROW	INT*2	1	na	Maximum number of rows (E-W) in output file
MAXCOL	INT*2	1	na	Maximum number of columns (N-S)in output file
TOPLAT	REAL	1	Deg	Latitude of North most row
LFTLON	REAL	1	Deg	Longitude of West most column
DLAT	REAL	1	Deg	N-S distance between sequential rows

DLON	REAL	1	Deg	E-W distance between sequential columns

Two arrays are written after the header record:

Variable	Type	Dim	Unit	Purpose
M	INT*2	(100,250)	m	Filtered bathymetry data
MBAR	INT*2	(100,250)	na	Water mass indexes

2.5.3 TL File Structure

There are three types of transmission loss files as summarized in Table 2-1. The first two, tlsrc.RID and tlrcv.RID provide transmission loss data for areas surrounding the source and receiver respectively. Data are provided for numerous ranges along each of numerous radials at regularly spaced bearings. The data for each radial comprises a record within the file. The data from each of these two files provides information for a plan view plot.

Table 2-1. Types of Transmission Loss Files

File Name	# Data Records	# Modes	# Depths	Transmission Loss Coverage
tlsrc.RID	# radials	1	3,4,6,7	area around source
tlrcv.RID	# radials	1	3,4,6,7	area around source
tldir.RID	1	10	1	source to receiver only

The last file, tldir.RID provides data for numerous ranges along only one radial. The origin is the source and

the bearing is from source to receiver. There is therefore only one data record in this type of file.

The source and receiver TL files are similar in that all modes are summed resulting in a single intensity at every range step. The direct blast file has multiple modes (10 maximum) and therefore has multiple intensities at each range step.

Record Length

In TL files, there are as many records as there are radials. The record length is constant within a file, but will vary between files.

Header

The following table shows, in the order written, the data in the header record. Two of the variables, FREQS_RCV and MODE_ANG_RCV are actually arrays of length one. This is for future expansion. However, as far as the disk file is concerned, arrays of length one are exactly the same as scalars. The number of bytes of data in the header record is 93.

Variable	Type	Dim	Unit	Description
RCV_LAT_DEG	INT*4	1	deg	Degrees of latitude of origin.
RCV_LAT_MIN	INT*4	1	min	Minutes of latitude of origin.
RCV_LAT_NS	CHAR*1	1	na	'N' or 'S': North or South for latitude.
RCV_LON_DEG	INT*4	1	deg	Degrees of longitude of origin.

RCV_LON_MIN	INT*4	1	min	Minutes of longitude of origin.
RCV_LON_EW	CHAR*1	1	na	'E' or 'W': East or West for longitude.
RANGE_MAX_RCV	REAL*4	1	nm	Maximum range to which the TL calculation is carried.
RANGE_STEP_RCV	REAL*4	1	nm	Maximum difference in range between TL calculations.
NUM_RANGE_RCV	INT*4	1	na	The maximum number of ranges per record, which, in part, determines the record length.
BEARING_MIN_RCV	REAL*4	1	deg	Bearing of first TL radial in the file.
BEARING_MAX_RCV	REAL*4	1	deg	Bearing of last TL radial in the file.
BEARING_STEP_RCV	REAL*4	1	deg	Bearing increments between consecutive TL radials.
NBEAR_RCV	INT*4	1	na	Number of TL radials (or bearings or data records).
NFREQS_RCV	INT*4	1	na	Number of frequencies = 1.
FREQS_RCV	REAL*4	1	Hz	Array of sound frequencies.
NTGTS_RCV	INT*4	1	na	Number of reflector depths.
TGT_DEPTHS	REAL*4	7	ft	Array of reflector depths.
RCV_DEPTH	REAL*4	1	ft	Depth of origin.
RCV_MONTH	CHAR*3	1	months	Month of year.
MODE_ANG_RCV	REAL*4	1	deg	Array of mode angles.

Data Records

Source and Receiver Files

The general outline of the data record for Transmission Loss files for Source or Receiver files is shown in Table 2-2 and details are shown in Table 2-3. The arrangement of TL values is shown in Table 2-4.

Table 2-2. TL Data Record -- Source and Receiver

Single Bearing Value
Number of Actual Ranges
Array of Ranges
Array of Transmission Losses Summed Over Modes for Ranges and Depths
Array of Transmission Times for Ranges and Depths for Mode of Maximum Power
Array of Spread of Transmission Times to Target for Ranges and Depths

Table 2-3. Variables for TL Data Record -- Source and Receiver

Meaning	Unit	Variable	Dimension	Type
Bearing	deg	TL_BEAR_RCV	1	REAL*4
# Ranges		NRANGE_RCV	1	INT*4
Range	nm	TL_RANGE_RCV	400	REAL*4
Trans Loss	ratio	TL_RCV	7*, 400	REAL*4
Trans Time	sec	TIME_RCV	7*, 400	REAL*4
Spread	sec	TSPREAD_RCV	400	REAL*4

* Designates a variable dimension. The maximum is shown.

Table 2-4. TL Depth in Order of Index

Surface
Target
Volume, Fish
Shallow Seamounts
Middle Seamounts
Deep Seamounts
Bottom

TL is computed along equally spaced bearings at a constant range step within each bearing. The number of range steps is set by parameter NUM_RANGE_RCV in the header. The maximum number of range steps is set to 400. If less than the maximum number is used, space is not saved.

The arrays which store TL as a function of range are two dimensional arrays, the inner dimension corresponds to target depths, as shown in Table 2-4. Seamounts and volume are optional. If any depths are omitted, (no seamounts extracted) the remaining values are packed up, and space is saved, reducing the length of the file. Seamounts are used or not used as a group. If at least one seamount is extracted there will be three additional depths along which TL is computed. The possible number of TL target depths are therefore 3, 4, 6, and 7.

Variable	Purpose
TL_BEAR_RCV	The bearing is a single value for the record in degrees, with zero degrees Indicating north.
NRANGE_RCV	This is the number of actual ranges used for this bearing. It is the maximum useful index in the one dimensional arrays and in the outer index of the two dimensional arrays.
TL_RANGE_RCV	The range is an array of distances from the origin to each distance for which a TL is computed. The units are nautical miles.
TL_RCV	For each range and for each depth, this is the transmission loss summed for all modes. The units are the linear intensity ratio, as opposed to logarithmic.
TIME_RCV	For each range and for each depth, this is the transmission time of the dominant mode in seconds.
TSPREAD_RCV	For the target depth only, this is the difference between the travel times for a selected subset of modes. This subset consists of one to five modes including the dominant mode plus the next four modes ranked by power, but including no modes with less than half the power of the dominant mode. The units are seconds.

The general outline of the data record for Direct Blast Transmission Loss files is shown in Table 2-5 and details are shown in Table 2-6. There are five types of variables which are described in Table 2-6. Three of the five variable types are arrays. One of these is one dimensional, and two are two dimensional. The maximum index of the one dimensional array as well as the maximum index of the outer dimension of the two dimensional arrays is the value of NUM_RANGE_RCV in the header. The index 1 to NUM_RANGE_RCV corresponds to the ranges, starting at the origin. If less than the maximum number is used, space is not saved. For the

two dimensional arrays, the inner dimension corresponds to modes of which there are always ten.

<u>Direct Blast File Organization</u>

Table 2-5. TL Data Record -- Direct Blast

Single Bearing Value
Number of Actual Ranges
Array of Ranges
Array of Transmission Losses for Ranges and Modes
Array of Transmission Times for Ranges and Modes

Table 2-6. Variables for TL Record -- Direct Blast

Meaning	Unit	Variable	Dimension	Type
Bearing	deg	TL_BEAR_RCV	1	REAL*4
# Ranges		NRANGE_RCV	1	INT*4
Range	nm	TL_RANGE_RCV	N	REAL*4
Trans Loss	ratio	TL_RCV	10, N	REAL*4
Time	sec	TIME_RCV	10, N	REAL*4

Description of variables in the Direct Blast TL record.

Variable	Purpose
TL_BEAR_RCV	This is the bearing from source to receiver, and is a single value in degrees, with zero degrees indicating north.
NRANGE_RCV	This is the number of actual ranges used. It is the maximum useful index in the one dimensional arrays and of the outer index of the two dimensional arrays.
TL_RANGE_RCV	The range is an array of distances from the source to each distance for which a TL is computed. The units are nautical miles.
TL_RCV	This is the transmission loss for each range and for each mode. The units are the linear intensity ratio, as opposed to logarithmic.
TIME_RCV	This is the transmission time for each range and for each mode.

Section 3

REVERB ENHANCEMENTS: SEAMOUNTS, DIRECT BLAST AND VOLUME

3.1 OVERVIEW OF ENHANCEMENTS

REVERB combines the TL data generated by ASERT and computes the reverberation due to the environment and the echo from the target. Volume reverberation along with returns from seamounts and the direct blast have been included in REVERB. An additional plot file has been added which displays the bottom reverberation with seamount returns.

The VOLUME reverb calculation proceeds as does the bottom and surface reverberation. For each range step along each bearing from the receiver a constant volume scattering coefficient is combined with the volume TL to produce volume reverberation as a function of range and bearing. The output file "volrvb.RID" has the same structure as the bottom and surface reverb files.

The processing of SEAMOUNTS is quite different from previous reverberation calculations. A value is computed if a seamount is in the "vicinity" of the current REVERB range and bearing. A file is output which contains discrete returns at the bearings and ranges coincident with seamounts.

The DIRECT BLAST processing is unique in that REVERB reads a file which contains the TL along a single radial from source to receiver. The associated times and levels corresponding to the receiver position are determined. Each mode is scaled by the source level.

A major enhancement to REVERB is the inclusion of a "Dual Resolution" mode which is employed when seamount and direct blast contributions are computed. This mode is in addition to the computation of the smoothly varying (surface, bottom, volume) reverberation and target echo.

3.2 SEAMOUNT PROCESSING

For each seamount the echo level and time duration is computed. The processing of seamounts proceeds as follows:

- Open and read seamount statistics file "SEAMOUNT.RID"

- Reduce seamount target strength if it occupies more than one REVERB bearing sector

- Sort seamounts by bearing and range

- Determine TL from source and receiver to each seamount

  REVERB averages the TL from the source and receiver if the seamount subtends multiple ASTRAL TL depths. The TL to each seamount is determined by integrating the intensities over the ASTRAL TL depth intervals that the seamount spans.

- Compute seamount arrival time

  The arrival time of the seamount is the sum of the source and receiver travel times. These travel times are computed along the TL depths which the seamount spans. These times are averaged if the seamount spans multiple TL depths.

- Compute seamount time spread

  The time spread associated with each seamount is proportional to the seamount base radius.

  Time_spread = 2*r/c

  where r = seamount radius
  c = Velocity of sound in water

- Compute seamount return level

  The return level of each seamount is determined by the following equation:

$$SR = SL - SRC\_TL - RCV\_TL + TS - 10 \log \left(\frac{\text{time spread}}{\text{pulse length}} \right)$$

  Where SR = Seamount Return Level
  SL = Source Level
  SRC_TL = Average TL from source to seamount
  RCV_TL = Average TL from receiver to seamount
  TS = Seamount target strength
  Time_spread = 2*r/c

  The division of the seamount return level by the Time_spread reduces SR to compensate for the stretching of the returned signal. Pulse length of the emitted signal is taken as 1 sec in REVERB.

- Write entry to seamount reverb file "DISTSM.RID"

3.3 DIRECT BLAST PROCESSING

The direct blast consists of a series of modes (10 maximum) for each range step along the source to receiver bearing. REVERB reads the TL file and computes the time and level for the direct blast. Processing the direct blast proceeds as follows:

- Open and read direct blast TL file
- Select all modes within narrow range of the receiver
- Interpolate in range the levels and times at the receiver
- Scale the direct blast arrivals by the source level
- Write direct blast file

3.4 OUTPUT FILE MODIFICATIONS AND ADDITIONS

REVERB Creates two bottom reverberation density files. One of these files (botrvb.RID) is used by SYSMOD, the other (searvb.RID) is used for graphic display. These files are identical except one contains seamount echos and the other does not.

The bottom reverberation density with seamounts (searvb.RID) is created so the user can view the positions of the seamounts. SYSMOD combines the discrete seamount returns in file "DISTSM.RID" with the bottom reverberation file (botyrvb.RID) on a high resolution bearing-time grid. The flow diagram in Figure 1-1 shows the relationship of these files to the REVERB, SYSMOD and PLOTTING modules.

3.4.1 Display Bottom Reverberation File (searvb.RID)

The display only file is created by adding the seamount returns to the bottom reverberation computed over the low pass grid. The reverberation calculation is a

spatially coarse estimate with resolution determined by the sector size used by REVERB. A sector is the amount of area bracketed by sequential radials and lying between successive range steps. The seamount return must be placed in at least one of these sectors. Placing the seamount returns on this coarse mesh approximates their range, bearing and angular extent and gives the user information with respect to their positions.

3.4.2 Bottom Reverberation File used by SYSMOD (botrvb.RID)

The bottom reverberation file that is used by SYSMOD contains the reverberation contributions from the low pass grid. This file does not have the seamount returns added to it. SYSMOD combines this file (botrvb.RID) with the discrete seamount returns (DISTSM.RID) on a higher resolution bearing-time grid. This higher resolution grid results in a more accurate placement of each seamount.

3.5 SEAMOUNT REVERB FILE STRUCTURE

The seamount reverb file is a formatted file which contains the reverberation information that is used by SYSMOD. The file structure is as follows:

File Name : DISTSM.RID

A header value is written which defines the number of seamounts in the file:

Variable	Type	Dim	Unit	Description
NUM_SE	INT	1	na	Number of seamounts in file

A record for each seamount is written after the header value. The maximum number of records is 200.

Variable	Type	Unit	Description
SEAM_TIME	REAL	sec	Initial time of seamount arrival
SEAM_TIME	REAL	sec	Final time of seamount arrival
SMBEAR	REAL	rad	Bearing, receiver to seamount
SM_ANG_SPREAD	REAL	rad	Angle seamount subtends at the receiver
SRC_SEAM_BEAR	REAL	rad	Source to seamount bearing
SEAM_LEVEL	REAL	dB	Seamount reverberation level normalized to on second

Section 4
SYSMOD OVERVIEW: SEAMOUNT AND DIRECT BLAST PROCESSING

4.1 SEAMOUNT AND DIRECT BLAST PROCESSING

SYSMOD combines the smoothly varying reverberation data (surface, bottom and volume) with the discrete returns from the direct blast and seamounts. The reverberation data is supplied to SYSMOD on equally spaced range and bearing grids while the discrete seamount returns are random with respect to bearing and range. SYSMOD sums the surface, bottom and volume reverberation with the seamount and direct blast arrivals. The summed reverberations are amplitude weighted by the horizontal beam pattern and written to an output file which contains the beam reverberation level as a function of time and bearing.

The addition of the seamount and direct blast arrivals result in an increase in beam reverberation. Seamount and direct blast arrivals occur over small azimuth angles and have relatively high levels.

4.2 BEAM REVERBERATION INCLUDING SEAMOUNTS AND THE DIRECT BLAST

Beam reverberation is computed for a horizontal array along equal bearing increments. The bearing increment is set equal to the array beamwidth at broadside or to an internally set minimum step. The reverberations are summed for each bearing and weighted with respect to the horizontal beam pattern. For a point (or vertical) receiver the reverberations are summed with equal amplitude weighting for all directions.

The reverberations are summed before the discrete returns from seamounts and the direct blast are considered. The arrival times of each seamount and the direct blast is determined and the received level is weighted by the horizontal beam pattern.

The SYSMOD processing proceeds as follows:

- Open the reverberation files (botrvb.RID, volrvb.RID, surrvb.RID)

- Sum reverberation over all bearings and times

For each array steer direction these processes are repeated

- Multiply summed reverberation by beam pattern

- Add seamount returns and amplitude weight with respect to the beam pattern

- Add direct blast and amplitude weight with respect to the beam pattern

- Write beam reverberation to output file (beamrvb.RID)

SYSMOD cycles through all the seamount and direct blast arrivals computing their levels and weighting by the beam pattern. These discrete events are placed on a time-bearing grid which has a fixed angular and time resolution. Seamounts which subtend greater than a beam width appear across multiple beams. The beam width and the time increment place the upper limit on the resolution of the discrete arrivals.

Section 5

APPENDIX: FILE DEFINITIONS USED IN THIS DOCUMENT

The following table lists the file names which are used in this document. The suffix RID is appended to the end of each file which represents the user defined three character Run Identifier.

File Name	Written by Program	Read by Program(s)	Description
tlsrc.RID	ASERT	REVERB PLOT	The transmission loss as a function of range and bearing from the source.
tlrcv.RID	ASERT	REVERB PLOT	The transmission loss as a function of range and bearing from the receiver.
tldir.RID	ASERT	REVERB	The transmission loss for individual modes along the bearing from source to the receiver.
SEAMOUNT.RID	ASERT	REVERB	The position, target strength, height, depth, radius and TL depth for each seamount in the area of interest.
FILBATHY.RID	ASERT	ASERT	The low pass grid and the water mass index numbers for the area of interest. Temporary file which is deleted after ASERT is completed.
botrvb.RID	REVERB	SYSMOD	The bottom reverberation recorded at the receiver as a function of range and bearing.

surrvb.RID	REVERB	SYSMOD PLOT	The surface reverberation recorded at the receiver as a function of range and bearing.
volrvb.RID	REVERB	SYSMOD	The volume reverberation recorded at the receiver as a function of range and bearing.
searvb.RID	REVERB	PLOT	The bottom reverberation recorded at the receiver as a function of range and bearing with the seamount returns superimposed.
DISTSM.RID	REVERB	SYSMOD	The arrival levels and times of the seamounts along with their positions in bearing and time.
beamrvb.RID	SYSMOD	PLOT	The combination of the bottom, surface and volume reverberation with the seamount and direct blast returns.